AF

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of:	)	
	)	
Ko et al.	)	Attorney Docket No: LAM2P257
	)	
Application No: 09/894,230	)	Group Art Unit: 1756
	)	
Filed: June 27, 2001	)	Examiner: RUGGLES, John S.
	)	
For: APPARATUS AND METHOD FOR ARGON PLASMA INDUCED ULTRAVIOLET LIGHT CURING STEP FOR INCREASING SILICON-CONTAINING PHOTORESIST SELECTIVITY	)	Date: June 20, 2005

CERTIFICATE OF MAILING
I hereby certify that this correspondence is being deposited with the United States Postal Service as First Class Mail in an envelope addressed to: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450 on June 20, 2005.

Signed: _____
Melinda M. Ward

TRANSMITTAL OF APPEAL BRIEF
(PATENT APPLICATION – 37 CFR 1.192)

Appeal Brief – Patents
Commissioner for Patents
P. O. Box 1450
Alexandria, VA 22313-1450

Sir:

This Appeal Brief is in furtherance of the Notice of Appeal filed in this case on October 25, 2004 and the Notification of Non-Compliant Appeal Brief mailed May 20, 2005. This Appeal Brief is transmitted in triplicate:

This application is on behalf of:

☐ Small Entity ☒ Large Entity

Pursuant to 37 CFR 42.20(b)(2), the fee for filing the Appeal Brief is:

☐ $250.00 (Small Entity) ☒ $500.00 (Large Entity) which was previously paid on December 27, 2004.

The proceedings herein are for a patent application and the provisions of 37 CFR 1.136 apply:

☐ Applicant petitions for an extension of time under 37 CFR 1.136 (fees: 37 CFR 1.17(a)-(d)) for the total number of months checked below:

Months	Large Entity	Small Entity
☐ one	$ 120.00	$60.00
☐ two	$ 450.00	$225.00
☐ three	$1020.00	$510.00
☐ four	$1590.00	$795.00

If an additional extension of time is required, please consider this a petition therefor.

☐ An extension for ** month has already been secured and the fee paid therefor of $0.00 is deducted from the total fee due for the total months of extension now requested.

☒ Applicant believes that no extension of term is required. However, this conditional petition is being made to provide for the possibility that Applicant has inadvertently overlooked the need for a petition and fee for extension of time.

Total Fees Due:

Brief in Support of an Appeal	$500.00 (previously paid)
Extension Fee (if any)	$0.00
Total Fee Due	**$0.00**

☒ Check No. 13163 in the amount of $500.00 was previously submitted with the Appeal brief filed December 27, 2004.

☒ Charge any additional fees or credit any overpayment to Deposit Account No. 50-0850, (Order No. LAM2P257). Two copies of this transmittal are enclosed.

Respectfully submitted,
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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

Application for Patent

FOR:

APPARATUS AND METHOD FOR ARGON PLASMA INDUCED ULTRAVIOLET LIGHT CURING STEP FOR INCREASING SILICON CONTAINING PHOTORESIST SELECTIVITY

APPEAL BRIEF

EX PARTE Francis Ko et al.

Application No. 09/894,230
Filed June 27, 2001
Technology Center/Art Unit 1756

Submitted in accordance with 37 C.F.R. §41.67

CERTIFICATE OF MAILING

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Signed: _____
Melinda M. Ward

MARTINE PENILLA & GENCARELLA, LLP
Attorneys for Appellant

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I. REAL PARTY IN INTEREST

The real party in interest is Lam Research Corporation, the assignee of the present application.

II. RELATED APPEALS AND INTERFERENCES

The undersigned is not aware of any related appeals or interferences.

III. STATUS OF THE CLAIMS

Claims 16-24 and 37-39 are pending in the subject application. Claims 16-24 and 37-39 have been finally rejected and are on appeal. Claims 1-15 and 25-36 have been cancelled.

IV. STATUS OF THE AMENDMENTS

Appellants have not submitted any amendment subsequent to the final rejection of August 24, 2004. The most recent amendment submitted on July 6, 2004 has been entered.

V. SUMMARY OF THE CLAIMED SUBJECT MATTER

The claims under appeal of the present invention provide a method for an improved selectivity of a silicon-containing photoresist which in turn, allows for amelioration of a subsequent etch profile. In one embodiment, a hardened layer is formed in a silicon-containing photoresist by exposing the developed silicon-containing photoresist to ultraviolet (UV) light. The UV light is generated by striking a plasma containing an inert

gas such as neon. The exposure to the UV light causes the polymer chains of the silicon containing photoresist to cross link, thereby creating a hardened layer.

The hardened layer of the silicon-containing photoresist has an increased selectivity relative to an underlying photoresist layer or an underlying interlayer dielectric (ILD). Accordingly, the increased selectivity allows for tighter control of future etching processes, particularly with respect to dual damascene processing. Just as significant, the formation of the hardened layer can take place in an etch chamber. Correspondingly, the etch chamber is configured to control various process parameters as discussed below. In addition, once the silicon-containing photoresist has been hardened, downstream etching processes may occur in the etch chamber without the need to remove the wafer. Consequently, wafer throughput is increased by combining fabrication steps into a single system.

The present invention as defined by claim 16, provides a method for converting a top portion of a developed silicon containing photoresist layer (previously exposed to UV light from a lamp or laser for defining the resist pattern), where the silicon containing photoresist layer is disposed over a non-silicon containing photoresist layer (see page 9, lines 18-21, and page 10, lines 8-15). The developed silicon containing photoresist layer (see 110 of Figure 2) is exposed to ultraviolet (UV) light (see page 11, lines 5-14), thereby cross-linking polymer chains in the silicon containing photoresist. The cross-linking activated by the UV light results in converting a top portion of the developed silicon containing photoresist layer to a hardened layer (see 138 of Figures 3 and 4, 158 of Figure 5 and page 11, lines 19-22). The non-silicon containing photoresist layer (see 116 of Figures 2-4) is unaffected by the UV light exposure as a result of not containing the cross-linking agent, i.e., silicon (see page 12, lines 15-19). As stated in the application on page 9

at the end of the first full paragraph, the exposure to UV light prior to the development of the photoresist is distinct from the embodiments of the present invention, which occur post exposure.

Claim 37 provides a method for increasing the selectivity of a top photoresist disposed over a bottom photoresist. The method includes the features of applying a first non-silicon containing photoresist layer (see 116 of Figures 2-4) over a substrate and applying a second silicon-containing photoresist layer (see 110 of Figures 1-4) over the first photoresist layer (see page 9, lines 18-20). The second photoresist layer is then developed by exposure to UV light (see 102 of Figure 1, and page 9, lines 4-12). Post development, a plasma is generated in the etch chamber wherein the plasma generates ultraviolet (UV) light (see 136 Figure 3, and page 11, lines 11-16), thereby exposing the developed second photoresist layer and the exposed first non-silicon containing photoresist layer to plasma generated UV light (See Figures 3 and 5 and the corresponding text on pages 11-13, and 15-17, respectively). Due to the second exposure to UV light generated from the plasma, a portion of the top layer of the top photoresist is converted to a hardened layer (see 138 of Figure 3, page 11, lines 20-24, and page 16, lines 14-17), which has an increased selectivity relative to the underlying photoresist layer (see 116 of Figure 3).

VI. GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

Whether Claims 16 and 17 are Patentable under 35 U.S.C. § 103(a) over Sato (U.S. Patent No. 6,337,163) in view of Young et al. (U.S. Patent No. 6,255,022) further in view of Schroeder et al. (U.S. Patent No. 6,379,869).

Whether Claim 18 is Patentable under 35 U.S.C. § 103(a) over Sato (U.S. Patent No. 6,337,163) in view of Young et al. (U.S. Patent No. 6,255,022) further in view of Schroeder et al. (U.S. Patent No. 6,379,869) further in view of Tsai et al. (U.S. Patent No. 5,899,748).

Whether Claims 19-23 and 37-39 are Patentable under 35 U.S.C. § 103(a) over Sato (U.S. Patent No. 6,337,163) in view of Young et al. (U.S. Patent No. 6,255,022) further in view of Schroeder et al. (U.S. Patent No. 6,379,869) further in view of Tsai et al. (U.S. Patent No. 5,899,748) further in view of Kishimura (U.S. Patent No. 5,123,998) further in view of Singh et al. (U.S. Patent No. 6,479,820) further in view of George et al. (U.S. Patent No. 4,980,563).

Whether Claim 24 is Patentable under 35 U.S.C. § 103(a) over Sato (U.S. Patent No. 6,337,163) in view of Young et al. (U.S. Patent No. 6,255,022) further in view of Schroeder et al. (U.S. Patent No. 6,379,869) and further in view of Rangarajan et al. (U.S. Patent No. 6,451,512).

VII. ARGUMENTS

A. The combination of Sato (U.S. Patent No. 6,337,163) in view of Young et al. (U.S. Patent No. 6,255,022) further in view of Schroeder et al. (U.S. Patent No. 6,379,869) would not have suggested to one of ordinary skill in the art the subject matter of claims 16-17.

Claims 16 and 17 were rejected under 35 U.S.C. § 103 as being unpatentable over U.S. Patent 6,337,163 to Sato in view of U.S. Patent 6,255,022 to Young et al. and further in view of U.S. Patent 6,379,869 to Schroeder et al. The Examiner asserts that the method defined in independent claim 16 would have been obvious to one having ordinary skill in the art in light of the teaching of Sato in view of Young and Schroeder.

Sato provides for patterning a photoresist through the application of light exposure and electron beam exposure. The embodiments of Sato further disclose methods for

aligning the two patterns. Each configuration of Sato requires that the underlying film 12, which may be an organosilicon compound, be below a resist layer 13. Sato describes two embodiments. A first embodiment is described through Example 1, where the underlying film 12 is limited to an organosilicon compound (See column 99, line 32 through column 100, line 36). This is due to this first embodiment requiring a material whose etching rate would be lowered by the irradiation of a charged beam (See column 5, lines 53-62). Thus, the electron beam exposure results in the conversion of the organosilicon compound to a silicon oxide/carbide like film (See column 5, lines 64-67). Moreover, the first embodiment uses UV light to develop the photoresist mask (See column 97, lines 43-48). The exposed substrate is then baked and developed. Thus, the first embodiment of Sato does not teach or disclose applying UV light to the developed photoresist, as acknowledged by the Examiner.

The second embodiment discussed by Sato uses a material other than an organosilicon compound as the underlying layer. According to the Examiner, Example 5 provides a potential use for a non-organosilicon underlayer in a similar process that involves similar patterning of an overlying resist before etching an underlying layer. Appellants respectfully traverse this characterization of the second embodiment. As depicted in Figures 5A-5E, the second embodiment defines a first resist pattern for a top resist layer, determines the position of the first resist pattern and then defines a second resist pattern for the top resist layer. The first resist pattern is defined through exposure to an electron beam and then developed, and the second resist pattern is defined through exposure to a KrF excimer laser. This second pattern is then developed by baking and application of a developing solution (See column 107, line 56 through column 108, line 2). The present invention, as claimed, has nothing to do with aligning multiple resist patterns.

In particular, the present invention defines a developed silicon-containing photoresist layer over a non-silicon containing photoresist layer. The developed photoresist layer is then exposed to UV light to convert a top portion of the developed silicon containing photoresist. Accordingly, the multi-resist process defined by Sato in Example 5, where alignment of the multiple resists is critical, is not similar to the claimed invention at all.

Furthermore, the Appellants do not understand the Examiner's basis for comparing Figures 1C and 1D of Sato to come to the conclusion that the electron beam organosilicon regions have a greater resistance to subsequent etching than the etching mask. Appellants respectfully submit that this conclusory assertion by the Examiner has no support in the specification of Sato. In fact, the specification states that both are equally excellent (See column 102 lines 11-22). Moreover, the specification goes on to state that the organosilicon layer defined as underlying layer 12 is highly etchable as compared to both the resist layer 13 and the exposure region 16, thus enabling the excellent anisotropic etching (See column 102, lines 16-30). Furthermore, the silicon oxide/carbide like film results from exposure of the underlying film to a charged beam, not ultraviolet light. Additionally, the charged beam is applied to define a pattern on the underlying film that is subsequently developed. The Examiner refuses to acknowledge that Sato requires that the silicon - silicon bond in the backbone chain of the organosilicon compound underlying film is highly etchable, which allows for an anisotropic etch to take place. Irrespective of these facts, Sato applies the charged beam or the UV light to an undeveloped resist layer, i.e., not post exposure.

The Examiner goes on to assert that Young teaches a bi-layer resist process for improving dimension control during subsequent etching of an underlying substrate. According to the Examiner, it would have been obvious to reverse the order of the

organosilicon and non-organosilicon resists of Sato so that the organosilicon resist is on the top layer as taught by Young. The Appellants respectfully submit that the Examiner is ignoring the teaching of Sato and not reading the references as a whole. That is, Sato teaches that the silicon-silicon bonds of the organosilicon layer is highly etchable and therefore, best suited for the bottom layer. The Examiner has provided no reasonable basis for modifying Sato as taught by Young as required under MPEP 2143, except that it is logical that the stronger etching mask should be the first line of defense. If this were the case, the Appellants respectfully submit that the anisotropic etch features will be lost as the ease with which the silicon-silicon bonds can be etched will cause the etch to exhibit isotropic behavior, as the bottom layer will no longer exhibit the anisotropic behavior resulting from the silicon-silicon bonds. Consequently, the Appellants submit that Sato and Young are incompatible, as Young would modify Sato unsatisfactory for its intended purpose (MPEP 2143), and one skilled in the art would not have modified Sato as taught by Young.

The Examiner further asserts that it would have been obvious to subsequently expose the top portion of the silicon containing resist as taught by Shroeder to convert it into a hardened layer for improving etching resistance. Schroeder teaches a single layer photoresist where the developed photoresist is treated by flood exposure to UV radiation to release a deprotecting agent. Afterwards, the photoresist layer is exposed to a silylating (see column 3, line 50 – column 5, lines 44, and the Example in column 5). Schroeder is silent as to exposing a developed top portion of silicon containing photoresist as Schroeder teaches exposing a non-silicon containing photoresist to UV light to release a deprotecting agent and then adding silicon through a silylation process.

In summary, the combination of the Sato, Young and Schroeder references would not have suggested to one having ordinary skill in the art the method operations specified in independent claim 16. The Examiner has failed to consider each reference in its entirety (MPEP 2141). The Appellants respectfully disagree with the Examiner's characterization of the references. As acknowledged by the Examiner, Satao fails to teach all of the claimed features of claim 16. The Appellants further submit that there is no motivation to combine the references as suggested by the Examiner for the reasons discussed above. Furthermore, each of the claim features of claim 16 is not taught by the combination of Sato, Young and Schroeder. Accordingly, the combination of the Sato, Young and Schroeder references does not establish a *prima facie* case of obviousness against independent claim 16 or dependent claim 17. Thus, the rejection of claims 16 and, 17 under 35 U.S.C. § 103(a) as being unpatentable over the combination of Sato, Young and Schroeder is improper and should be reversed.

B. The combination of Sato (U.S. Patent No. 6,337,163) in view of Young et al. (U.S. Patent No. 6,255,022) further in view of Schroeder et al. (U.S. Patent No. 6,379,869) further in view of Tsai et al. (U.S. Patent No. 5,899,748) would not have suggested to one of ordinary skill in the art the subject matter of claim 18.

The Examiner asserts that the method defined in claim 18 would have been obvious to one having ordinary skill in the art in light of the teachings of Sato in view of Young and Schroeder further in view of Tsai et al. (US Patent 5,899,748). Claim 18 depends from claim 16 and as such includes all of the features of claim 16. As mentioned above, the Examiner has acknowledged that Sato fails to teach or suggest the feature of a substrate with a developed silicon-containing photoresist layer disposed over a non-silicon containing photoresist layer or the feature of converting a top portion of the developed

silicon-containing photoresist layer to a hardened layer when the developed silicon-containing photoresist layer is disposed over a non-silicon containing photoresist layer. Tsai is silent to both of the aforementioned features, therefore, Tsai fails to cure the deficiencies of the combination of Sato, Young and Schroeder mentioned above with reference to the arguments presented for claims 16 and 17.

Additionally, according to the Examiner it would have been obvious to expose the photoresist to UV hardening as taught by Sato in an etching chamber that provides UV emission prior to etching with the expectation of simplifying processing. The Appellants note that Sato, Young, and Schroeder each require the baking and development of the exposed photoresist. Accordingly, using the chamber of Tsai to expose the undeveloped photoresist of Sato, Young or Schroeder does nothing for the simplification of processing as the exposed photoresist must be baked and developed. Thus, the etch chamber would have to accommodate these operations as well as silylation. Accordingly, it cannot be reasonably asserted that the combination of Sato, Young, Schroeder and Tsai would simplify processing, as asserted by the Examiner, when considering the references in their entirety. Thus, the rejection of claim 18 under 35 U.S.C. § 103(a) as being unpatentable over the combination of Sato, Young and Schroeder, and further in view of Tsai is improper and should be reversed.

C. The combination of Sato (U.S. Patent No. 6,337,163) in view of Young et al. (U.S. Patent No. 6,255,022) further in view of Schroeder et al. (U.S. Patent No. 6,379,869) further in view of Tsai et al. (U.S. Patent No. 5,899,748) further in view of Kishimura (U.S. Patent No. 5,123,998) further in view of Singh et al. (U.S. Patent No. 6,479,820) further in view of George et al. (U.S. Patent No. 4,980,563) would not have suggested to one of ordinary skill in the art the subject matter of claims 19-23 and 37-39.

Claims 19-23 each ultimately depend from claim 18 and further specify operating parameters in an etch chamber. The references cited by the Examiner, namely US patent No. 5,123,998 to Kishimura, U.S. Patent No. 6,479,820 to Singh et al., and U.S. Patent No. 4,980,563 to George et al. do nothing to cure the deficiencies mentioned above for the combination of Sato, Young, Schroeder and Tsai. Accordingly, claims 19-23 are not anticipated by the combination of Sato, Young, Schroeder and Tsai further in combination with Kishimura, Singh, or George.

Claim 37 includes the features of applying a first non-silicon containing photoresist layer over a substrate; applying a second silicon-containing photoresist layer over the first photoresist layer; and generating ultraviolet (UV) light from the plasma, thereby exposing the developed second photoresist layer and the exposed first non-silicon containing photoresist layer to plasma generated UV light, i.e. post photoresist development exposure. As the Examiner has failed to consider the references in their entirety, as discussed above with respect to claim 16, there is no motivation to combine the references as suggested by the Examiner. Additionally, even if the references were combined, each of the features of claim 37 is not taught by the combination as discussed above with respect to claim 16. For example, exposing a developed silicon containing photoresist to UV light is not disclosed in any of the references as discussed above. Thus, Appellants respectfully submit that at least the above stated features of claim 37 are not taught or disclosed by the combination of Sato, Young, Schroeder, and Tsai and any further combination with Kishimura, Singh, or George. As claims 38 and 39 depend from claim 37, claims 38 and 39 are patentable over the combination of Sato, Young, Schroeder, and Tsai and any further combination with Kishimura, Singh, or George. Thus, the rejection of claims 19-23 and 37-39 under 35 U.S.C. § 103(a) as being unpatentable over the combination of Sato, Young, Schroeder

and Tsai and any further combination with Kishimura, Singh, or George is improper and should be reversed. Quite simply, the references do not teach the claimed limitations and one skilled in the art would not have combined the references as suggested by the Examiner. The Examiner has failed to consider each reference in its entirety and has tried to piecemeal a rejection from a multitude of references without considering the motivation to combine the multitude of references.

D. The combination of Sato (U.S. Patent No. 6,337,163) in view of Young et al. (U.S. Patent No. 6,255,022) further in view of Schroeder et al. (U.S. Patent No. 6,379,869) and further in view of Rangarajan et al. (U.S. Patent No. 6,451,512) would not have suggested to one of ordinary skill in the art the subject matter of claim 24.

Claim 24 was rejected as being unpatentable over the combination of Sato, Young and Schroeder further in view of US Patent 6,451,512 to Rangarajan et al. Rangarajan references a silylation process performed after development, e.g., exposure to actinic radiation (see column 4 lines 56-65). Here again the silylation process occurs after exposure to the actinic radiation. Thus, Rangarajan does not resolve any of the deficiencies of Sato, Young and Schroeder with respect to the features of claim 16, from which claim 24 depends. Accordingly, the combination of Sato, Young, Schroeder and Rangarajan do not contain all of the claimed features of claim 24 and one skilled in the art would not have combined the references as suggested by the Examiner for the reasons discussed above with reference to claims 16 and 17. For at least this reason claim 24 is allowable over the combination of Sato, Young, Schroeder and Rangarajan.

Conclusion

For the foregoing reasons, the rejections of claims 16-24 and 37-39 under 35 U.S.C. §103(a) are improper and should be reversed. In formulating the rejections of these claims, the Examiner has improperly relied on technical assertions that are not supported by the Sato reference, has not considered each reference in its entirety, and improperly ignored features of the claimed invention. The Examiner has also not provided adequate motivation for one skilled in the art to combine the references. When considered objectively without the benefit of Appellants' teachings, the Sato, Young, and Schroeder references, or any of the other cited references, do not establish a *prima facie* case of obviousness against the claimed invention. Accordingly, Appellants respectfully submit that the obviousness rejections under 35 U.S.C. § 103(a) are in error, and request that the Board of Patent Appeals and Interferences reverse these rejections on appeal.

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VIII - CLAIMS APPENDIX

CLAIMS ON APPEAL

Claims 1-15 (Cancelled)

16. A method for increasing a selectivity of a photoresist, comprising:

providing a substrate with a developed silicon-containing photoresist layer disposed over a non-silicon containing photoresist layer, the developed silicon-containing photoresist layer including polymer chains containing silicon;

exposing the substrate and the developed photoresist layer to an ultraviolet (UV) light, the UV light emanating from a UV generating agent;

converting a top portion of the developed silicon-containing photoresist layer to a hardened layer, the hardened layer being created by cross-linking the polymer chains containing silicon, the cross-linking being activated by the UV light; and

performing an etch using the hardened layer.

17. The method as recited in claim 16, wherein the polymer chains are cross-linked through one of silicon-hydrogen bonds and silicon- CH_3 bonds.

18. The method as recited in claim 16, wherein the method operation of providing a substrate with a developed silicon-containing photoresist layer disposed over a non-silicon containing photoresist layer further includes,

placing the substrate in an etch chamber.

19. The method as recited in claim 18, wherein the exposing the substrate further includes,

controlling the flow rate of an inert gas to the chamber between about 1000 sccm and about 3000 sccm.

20. The method as recited in claim 19, wherein the inert gas is argon.

21. The method as recited in claim 20, wherein the UV generating agent is neon.

22. The method as recited in claim 21, wherein the flow rate of the neon is between about 0.2% and about 0.8% of the flow rate of the argon.

23. The method as recited in claim 21, wherein the method operation of exposing the substrate further includes,

striking a plasma composed of argon gas and neon gas.

24. The method as recited in claim 16, wherein the top portion of the developed silicon containing photoresist layer converted to the hardened layer is between about 5% and about 75% of the developed silicon containing photoresist layer.

Claims 25-36 (Clancelled)

37. In an etch chamber, a method for increasing a selectivity of a top photoresist disposed over a bottom photoresist, comprising:

applying a first non-silicon containing photoresist layer over a substrate;

applying a second silicon-containing photoresist layer over the first photoresist layer;

exposing a portion of the second photoresist layer to ultraviolet light generated through one of a mercury arc lamp and excimer laser;

removing the exposed portion of the second photoresist layer to define a developed second photoresist layer, resulting in a portion of the first non-silicon containing photoresist layer being exposed;

striking a plasma in the etch chamber;

generating ultraviolet (UV) light from the plasma, thereby exposing the developed second photoresist layer and the exposed first non-silicon containing photoresist layer to plasma generated UV light;

converting a top portion of the developed silicon-containing photoresist layer to a hardened layer, the hardened layer being created by cross-linking the polymer chains containing silicon, the cross-linking being activated by the plasma generated UV light; and

performing an etch operation.

38. The method of claim 37, wherein the method operation of generating ultraviolet (UV) light from the plasma, thereby exposing the developed second photoresist layer and the exposed first non-silicon containing photoresist layer to plasma generated UV light includes,

controlling a chamber temperature at about 0 degrees Celsius.

39. The method of claim 37, wherein the method operation of striking a plasma in the etch chamber includes,

introducing an inert gas and a UV generating gas selected from the group consisting of neon, xenon, helium, hydrogen, and krypton.